PATENT ABSTRACTS OF JAPAN

(11)Publication number : 08-203881

(43)Date of publication of application : 09.08.1996

(51)Int.Cl. H01L 21/3065
C23C 16/50
C23F 4/00
C30B 33/12
H01L 21/205
H05H 1/46

(21)Application number : 07-033050

(22)Date of filing : 30.01.1995

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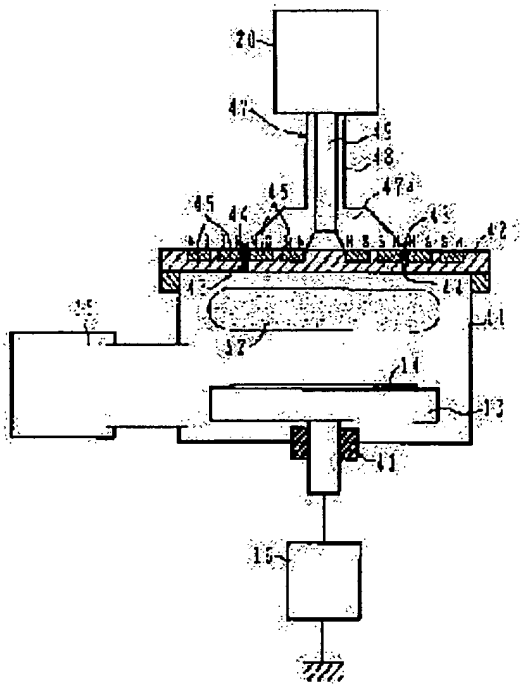
(54) SURFACE TREATMENT SYSTEM

(57)Abstract:

PURPOSE: To generate a low pressure high density plasma uniformly over a large area by providing a planar electrode made of a conductive plate having holes filled with a dielectric and vacuum sealing a vacuum vessel and radiating microwave, being fed from a coaxial tube of power supply mechanism, into the vacuum vessel through the holes of the conductive plate.

CONSTITUTION: A planar electrode 42 is provided with a slot part 43 serving as an antenna for radiating microwave. The planar electrode 42 is formed of a planar conductive member and holes are made through the planar electrode 42, at the slot part 43 thereof, and filled with a dielectric 44. The planar electrode 42 is fixed hermetically, as an upper wall, to the upper part of a vacuum vessel 11. Since the slot part 43 is filled with the dielectric 44, the vacuum vessel 11 can be sealed hermetically by means of the planar electrode 42 itself. Microwave power is fed from a microwave power supply 20 to the planar electrode 42 through a coaxial pipe 23.



LEGAL STATUS

[Date of request for examination]

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] Especially this invention performs surface treatment of a processed substrate about surface treatment equipment using the plasma generated by high frequency discharge, and relates to the surface treatment equipment used for dry etching or plasma CVD in a semiconductor device production process.
[0002]
[Description of the Prior Art] The example of the surface treatment equipment used for the dry etching which is one process of semiconductor device production is explained. With a circuit pattern formation process indispensable to semiconductor device production, in order to actually perform pattern formation, generate the plasma of the mixed gas which used as the principal component the gas which contains a halogen by discharge, the various active species in the plasma (for example, atom-like chlorine, an atom-like fluorine, a fluorine carbon compound, etc.) are made to react with a surface thin film, and, generally the dry etching technique of removing a thin film is used. The method of considering as a means to make gas plasma-ize, and generating the plasma using the interaction (electron cyclotron resonance) of the electric field by the supplied microwave and a magnetic field is learned. Generally the equipment using this approach is called ECR surface treatment equipment, and the equipment which used the air-core coil as a device for generating a magnetic field is widely applied to dry etching, plasma CVD, etc. Moreover, the flat-surface mold ECR surface treatment equipment which is the advanced type of ECR plasma use surface reaction equipment is also known for recently (for example, JP,5-182785,A).
[0003] An example of conventional flat-surface mold ECR surface treatment equipment is shown in drawing 5 , and the relation between the magnetic field in flat-surface mold ECR surface treatment equipment and electric field is shown in drawing 6 .
[0004] The vacuum lock of the vacuum housing 11 is carried out by the flange 12 in an upper part, and it equips a building envelope with the electrode 13 including a substrate maintenance device. The processed substrate 14 is arranged on an electrode 13. The interior of a vacuum housing 11 is decompressed by the exhauster style 15 to necessary level. The power for bias is supplied to an electrode 13 by the power source 16. The plane electrode 17 for emitting the power by microwave is formed in the building envelope, and the slot (through tube) 18 which operates as an antenna for microwave radiation is processed into the plane electrode 17 by the bottom in a vacuum housing 11. The formation location and configuration of a slot 18 are chosen as arbitration so that it may be suitable for microwave radiation. Two or more ring-like permanent magnets 19 for making the perimeter generate a magnetic field near the plane electrode 17 are arranged. In this example, the permanent magnet 19 is being fixed in the ring-like slot for magnet immobilization formed in the flange 12. Moreover, as a device which supplies microwave to the plane electrode 17, the coaxial tube 23 and the vacuum aperture 24 for coaxial-type microwave installation which consist of the microwave power source 20, an outer conductor 21, and an inner conductor 22 are prepared. Moreover, although illustration was omitted for simplification of explanation, a waveguide, an adjustment machine, single ****, a directional coupler, a coaxial waveguide converter, etc. are prepared if needed as a component which constitutes the microwave circuit between the microwave power source 20 and the plane electrode 17.

[0005] With above flat-surface mold ECR surface treatment equipment, after introducing predetermined gas to a predetermined pressure in a vacuum housing 11 using the gas feed system which is not illustrated, the power by microwave is introduced in a vacuum housing 11, gas is plasma-ized using the interaction of electric field and a magnetic field, and the plasma 25 is generated. The various particles with the high chemical activity within this plasma 25 are led to the front face of the processed substrate 14, and etch a front face using the chemical reaction in a substrate front face. Usually, in order to give energy to the cation which is one of the particles with high activity and to lead to the front face of the processed substrate 14, the bias power of high frequency is supplied to an electrode 13 using a power source 16.

[0006] Next, with reference to drawing 6 , the operation relation between a magnetic field and the electric field by microwave is explained. The electric field 32 of the microwave generated from the line of magnetic force 31 generated with the ring-like permanent magnet 19 and the slot 18 formed in the plane electrode 17 are shown in drawing 6 . In this example, the magnetic field strength in a vacuum housing 11 is the strongest near the slot 18, and the other side decreases in number more gradually inside a vacuum housing 11. The flux density with which the frequency of the microwave used for plasma production is used for, and 2.45GHz is generally satisfied of the ECR conditions at this time is 875 gauss. Therefore, the residual magnetic flux density of the ring-like permanent magnet 19 is determined so that the flux density generated with the ring-like permanent magnet 19 may generate flux density sides, such as 875 etc. gauss which is satisfied with the location (specifically location of several mm to several cm) a little distant from the slot 18 of ECR conditions. In the example of drawing 6 , it has the structure where magnetic field strength decreases gradually toward an ECR side by the propagation path of the microwave in the plasma 25 which reaches an ECR side from a slot 18. Moreover, a magnetic field 31 and the electric field 32 of microwave [/ near the slot 18 in a vacuum housing 11] cross at right angles mostly. In order that the above two conditions may make microwave spread to an ECR side and may generate the plasma 25 of high density, they are indispensable conditions.

[0007] By current, as for above conventional flat-surface mold ECR surface treatment equipment, evaluation as a source of the plasma has already been performed widely, and the evaluation as surface treatment equipment is also spreading.

[0008]

[Problem(s) to be Solved by the Invention] The greatest description of ECR surface treatment equipment is in the point that the plasma of a high consistency can be generated in low gas pressure, by using the resonance phenomenon of a magnetic field and microwave. However, 875 gauss is required as magnetic field strength for satisfying resonance conditions to 2.45GHz which is the frequency of the microwave usually used. On the other hand, it is required that the plasma for a thing with a diameter of about 250mm being used and processing this of the silicon wafer used for semi-conductor manufacture should also be uniform covering wafer area.

[0009] With the flat-surface mold ECR surface treatment equipment shown in drawing 5 , by using two or more ring-like permanent magnets, the fault accompanying the conventional equipment of the format of generating a magnetic field with a common air-core coil can be conquered, and effectiveness, such as facilitation of the magnetic field developmental mechanics by generating of the large area homogeneity plasma by use of a slot and adoption of a permanent magnet and equalization of the high-frequency power bias by a magnetic field not crossing a wafer front face, be attained.

[0010] However, the above-mentioned flat-surface mold ECR surface treatment equipment has a complicated device for installation of microwave, and especially, since the dependability of the coaxial-type vacuum aperture 24 is inadequate, the microwave power which can be supplied is restricted and it has the problem that generating of the high density plasma is difficult. When microwave power is enlarged, there is also a possibility that unusual discharge may occur around a slot 18, and now, it has come [moreover,] to be introduced into a semi-conductor production line from lack of the dependability as equipment.

[0011] The purpose of this invention is to solve the above-mentioned problem, it proposes the plane electrode for plasma production which has new structure, raises the dependability at the time of high density plasma generating, and is to offer the surface treatment equipment which can make homogeneity generate the plasma of high density over a large area by the low voltage force.

[0012]
[Means for Solving the Problem and its Function] The exhauster style to which the surface treatment equipment concerning the 1st this invention changes the inside of a vacuum housing and this vacuum housing into a reduced pressure condition, The gas installation device which introduces the gas for discharge in a vacuum housing, and the power feeder style which supplies the power by microwave in order to make gas discharge and to generate the plasma, It is surface treatment equipment equipped with the substrate maintenance device installed in a vacuum housing. The above-mentioned power feeder style It has the plane electrode fixed to a vacuum housing so that it may be formed with the conductive plate which has the hole with which it filled up with the dielectric and the vacuum lock of the inside of a vacuum housing may be carried out, it lets the hole of a conductive plate pass, and it is constituted so that the microwave supplied with the coaxial tube of a power feeder style may be emitted in a vacuum housing.
[0013] In the 1st this invention, the hole (slot section) with which it filled up with the dielectric not using the conventional coaxial tube and conventional vacuum aperture which are used for microwave installation is formed in a plane electrode, microwave is directly supplied to this plane electrode using a coaxial tube, and the homogeneous good high density plasma is easily generated by radiation of the microwave from the hole concerned. The hole with which it filled up with the dielectric as the slot section which emits the microwave in a plane electrode is the most practical. Moreover, **** which can eliminate the scarce coaxial-type vacuum aperture in dependability although it was required in order to make the slot section itself into the structure of bearing a vacuum lock and to supply microwave power conventionally by filling up the hole of the plane electrode for supplying the power of microwave in a vacuum housing with a dielectric.
[0014] The 2nd this invention is characterized by arranging two or more holes formed in the plane electrode in the radial location centering on one on a conductive plate, and supplying microwave near the core of a radial location in the 1st invention.
[0015] The 3rd this invention is characterized by forming the hole of a plane electrode as an arc on [of one] a circle or two or more concentric circles, and supplying microwave near the core of a circle or two or more concentric circles in the 1st invention.
[0016] In the 2nd and 3rd this inventions, the hole which forms the slot section is arranged preferably in the ring-like radial location, the power by microwave was effectively emitted in the vacuum housing, and it made the plasma generate in discharge space, and made it possible to use this.
[0017] In the 1st to 3rd invention, the 4th this invention installs two or more ring-like permanent magnets in a hole and the location in which it does not interfere with the conductive plate which forms a plane electrode, and is characterized by generating a magnetic field near the hole.
[0018] The magnetization direction of the ring-like permanent magnet with which the magnetization direction of two or more ring-like permanent magnets is radial [of a ring-like permanent magnet] in the 4th invention, and the 5th this invention adjoins each other is characterized by being hard flow mutually.

[0019] He makes the electric field by microwave, and the magnetic field by the permanent magnet cross at right angles by preparing the ring-like permanent magnet for magnetic field generation in a plane electrode directly, and making radial the magnetization direction of this ring-like permanent magnet, and is trying to produce the owner effect for the interaction of the magnetic field concerned and the electric field by microwave in the 4th and 5th this inventions.
[0020]
[Example] Below, the suitable example of this invention is explained based on an accompanying drawing.
[0021] In drawing 1 , the same sign is substantially given to the same element with the element explained by drawing 5 . The interior of a vacuum housing 11 is used as discharge space, and the electrode 13 with which the processed substrate 14 has been arranged to this interior is arranged. The electrode 13 is attached in the low wall of a vacuum housing 11 in the state of floating potential using the insulating material 41. Substrate maintenance ****** of the electrode 13 is carried out. The plane electrode 42 is formed in the upper wall part of a vacuum housing 11. The plane electrode 42 by this example serves also as the function for maintaining the building envelope of a vacuum housing 11 at a vacuum. Therefore, with the equipment by this example, the member which is conventionally equivalent

to the flange 12 of equipment was not used, but plane electrode 42 itself serves as the flange 12. The processed substrate 14 installed on the electrode 13 is arranged so that the plane electrode 42 of a vacuum housing 11 may be countered. In order to operate the equipment by this example as a discharge reactor, while ** is included, it connects with a power source 16 and the power for bias introduces the gas used for a discharge reaction using the gas installation device in which exhaust a vacuum housing 11 to a predetermined pressure, and it is not illustrated after that to a predetermined pressure using the **** device 15.

[0022] The structure of the plane electrode 42 and an operation are explained with reference to drawing 1 and drawing 2 . The slot section 43 which operates as an antenna for microwave radiation is formed in the plane electrode 42. The plane electrode 42 is formed using tabular conductivity members, such as a metal plate, and the slot section 43 is formed from the hole formed in the plane electrode 42 by penetrating, and the dielectric 44 with which this hole was filled up densely. the slot section 43 -- actual -- a hole -- although it is not the very thing, since the same operation, i.e., microwave, is substantially passed with the slot 18 of equipment conventionally and it has radiation into a vacuum housing, suppose that it is called the "slot section." Since the plane electrode 42 is attached in the upper part of a vacuum housing 11 so that a building envelope may become airtight as a upper wall of a vacuum housing 11, and the slot section 43 is filled up with the dielectric 44, the vacuum lock of the building envelope of a vacuum housing 11 is made possible by plane electrode 42 itself.

[0023] As conditions required of the dielectric 44 with which it fills up in the slot section 43, that dielectric loss is small, that airtightness is good, and having the thermal resistance which is a certain extent are mentioned. About airtightness, the need has that the adhesion of the wall of the conductive plate which forms the plane electrode 42, and a vacuum housing 11 is good. As an ingredient with which are satisfied of such conditions, there are organic materials, such as inorganic materials, such as glass, a quartz, and alumina ceramics, Teflon, polyimide, and silicon resin, and it is suitably chosen according to conditions, such as a type of gas used for the process of surface treatment, and microwave power to be used.

[0024] Moreover, as shown in drawing 1 and drawing 2 , in the external surface of the plane electrode 42, two or more ring-like permanent magnets 45 for generating a magnetic field are arranged. The magnetic circuit consists of this examples by arranging the four ring-like permanent magnet 45 with which paths differ mutually in concentric circle. The ring-like permanent magnet 45 is embedded in the slot of the shape of a ring formed in the external surface of the plane electrode 42. The ring-like permanent magnet 45 is magnetized so that the permanent magnet which is altogether magnetized by radial and adjoins each other may become hard flow mutually.

[0025] As shown in drawing 2 , the plane electrode 42 has a circular configuration. As for the above-mentioned slot section 43, it is desirable for two or more formation to be carried out and to be formed in the location of a radial from one point, such as the plane electrode 42, for example, a core etc. In the case of [43] this example (for example, the four slot sections), it sees from the central point from the inside in the tooth space between the 2nd permanent magnet 45 and the 3rd permanent magnet 45, and they are formed in the location of a radial. Since the four slot sections 43 are arranged on a ring configuration, each has the arc configuration. Moreover, the slot section 43 can also be formed among other ring-like permanent magnets, and can also arrange the slot section in a concentric circle location. Furthermore, by this example, although the example which used four ring-like permanent magnets 45 is shown, it may have the engine performance excellent in the direction of a different number depending on the applied purpose. Moreover, the actuation of the magnetization direction is completely the same about each permanent magnet 45 also as hard flow.

[0026] The plane electrode 42 shall have the reinforcement which does not deform practically to the differential pressure of atmospheric pressure and a vacuum on the structure, a gestalt, and the quality of the material. The thinner possible one of the thickness of the plane electrode 42 from the need of on the other hand making microwave spreading through the dielectric 44 inside the slot section 43 is desirable. The thickness of the plane electrode 42 is determined by the balance of these two conditions. As shown in this example, as for the slot section 43, it is effective practically by dividing a ring-like thing into two or more parts (this example 4), and forming the mediation part 46 to compensate the mechanical strength of the slot section 43 and to make the plane electrode 42 thin. If the die length of short **** and the divided slot section 43 is fully the quadrant of the wavelength of microwave, and more than

comparable as compared with the wavelength of the microwave which the width of face of the pons delivery part 46 uses for discharge, especially constraint does not exist about the die length of the pons delivery part 46, and the number of division.

[0027] Next, the structure of supply of the power of the microwave by this example and the generating approach of the plasma are explained. If microwave power is supplied from the microwave power source 20 to the plane electrode 42 through the coaxial tube 23 which consists of an outer conductor 21 and an inner conductor 22, it will let the dielectric 44 of the slot section 43 installed in the plane electrode 42 pass, and the power by microwave will be emitted to the interior of a vacuum housing 11. This microwave power is absorbed by the gas introduced in the vacuum housing 11, and the plasma 25 generates it in a vacuum housing 11. Predetermined surface treatment is performed to the front face of the processed substrate 14 using the operation which this plasma 25 has. If it sets up so that the conditions of the electron cyclotron resonance to the frequency of the microwave supplied may fill the reinforcement of the magnetic field generated from two or more ring-like permanent magnets 45 in the near space of the slot section 43 in a vacuum housing 11 at this time, generating effectiveness of the plasma 25 can be made very high.

[0028] The structure of microwave induction is explained. The power of the microwave used in surface treatment equipment is usually in the range of 10W to several kW. It is common to use that by which the bore of an outer conductor 48 was standardized by 20mm or 39mm as a coaxial tube 47 for making such power spread. On the other hand, although it differs about the diameter of the slot section 43 according to the process made into the purpose, the diameter of the processed substrate 14 and the diameter of extent comparable or small a little are usually needed. Since most things are contained in the range of 150 to 300mm, the diameter of the processed substrate 14 cannot connect the slot section 43 and a coaxial tube 47 directly. Therefore, the coaxial tube 47 which made partial 47a linked to the plane electrode 42 for discharge of an outer conductor 48 and an inner conductor 49 the shape of a taper constitutes from this example. By this, aggravation of the power use effectiveness by the impedance mismatch is prevented.

[0029] An operation with a magnetic field and the electric field by microwave is explained using drawing 3 . The electric field 51 of the microwave generated by the line of magnetic force (magnetic field) 50 generated with the ring-like permanent magnet 45 and the slot section 43 prepared in the plane electrode 42 are shown by drawing 3 . It has the structure where magnetic field strength decreases gradually toward an ECR side by the propagation path of the microwave in the plasma 52 which reaches an ECR side from the slot section 43. Moreover, line of magnetic force 50 and the electric field 51 by microwave cross at right angles over the whole mostly. The above two conditions are the term of a Prior art, and in order they to make microwave spread to an ECR side and to generate the plasma of high density, they are indispensable as they were already described. Also in this example, by making radial the magnetization direction of two or more ring-like permanent magnets 45, and making mutually the magnetization direction of the adjacent ring-like permanent magnet 45 into hard flow, the generation of the plasma in which the interaction of the same magnetic field as conventional flat-surface mold ECR surface treatment equipment and electric field became possible, and the advantage of ECR was employed efficiently is possible so that clearly from the comparison of drawing 3 and drawing 6 .

[0030] Drawing 4 shows the 2nd example of the surface treatment equipment concerning this invention. The slot section 43 is formed in radial in the shape of a crank inside the plane electrode 42, and the dielectric 44 is filled up with this example like the 1st example. As for the location of the slot section 43, it is desirable to consider as between a No. 2 side and the 3rd two ring-like permanent magnets 53, and to double with the center position of the magnet width of face of the ring-like permanent magnet 53 of a No. 2 side in the electrode surface by the side of a vacuum in the electrode surface by the side of atmospheric air, from the inside. The quality of the material of the dielectric 44 with which it is filled up in this slot section 43 is chosen like the 1st example. Moreover, let the magnetization direction of two or more ring-like permanent magnets 53 be the shaft orientations of a ring configuration as well as [conventionally] the case of equipment in this example. in this example, the arrangement relation between a magnetic field and microwave electric field showed this to drawing 6 -- it is because it becomes being the same as that of the case of equipment conventionally.

[0031] In each above-mentioned example, although the ring-like permanent magnets 45 and 53 were built into the plane electrode 42, it can also arrange on the outside of the flat-surface top electrode 42.

[0032]

[Effect of the Invention] By the above explanation, according to this invention, it sets to flat-surface mold ECR surface treatment equipment so that clearly. devising in the structure of a plane electrode, and the magnetization direction of a ring-like permanent magnet -- dependability, since the low conventional vacuum aperture for microwave installation was eliminated and generating of the unnecessary discharge inside a slot was abolished It was stabilized in flat-surface mold ECR surface treatment equipment, and the high density plasma was generated efficiently, and the homogeneity of surface treatment could be kept good to the processed substrate, and practicality was raised. Especially, according to this invention, in surface treatment equipments which are plasma process units, such as a dry etching system and a CVD system, various kinds of high speeds and uniform large area processing are attained.

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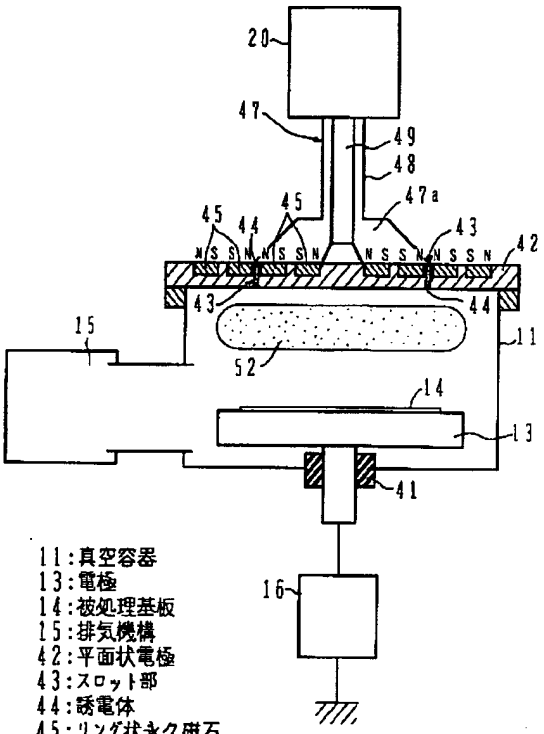
Drawing selection Representative drawing



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(19)日本国特許庁（ＪＰ）　(12)公開特許公報（A）　(11)特許出願公開番号

特開平8－203881

(43)公開日　平成８年(1996)８月９日

(51)Int.Cl.[6]	識別記号	庁内整理番号	ＦＩ	技術表示箇所
Ｈ０１Ｌ　21/3065				
Ｃ２３Ｃ　16/50				
Ｃ２３Ｆ　4/00		D		
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審査請求　未請求　請求項の数５　ＦＤ　（全 ７ 頁）　最終頁に続く

(21)出願番号　特願平7－33050

(22)出願日　平成７年(1995)１月30日

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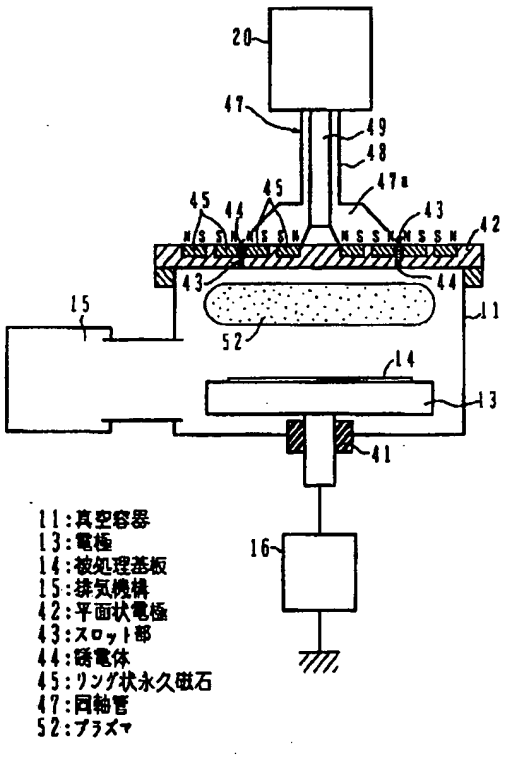
(54)【発明の名称】　表面処理装置

(57)【要約】

【目的】　表面処理装置において、高密度プラズマ発生時の信頼性を高め、低圧力で高密度のプラズマを大面積にわたって均一に発生させることができるプラズマ生成用平面状電極を提案する。

【構成】　真空容器11と、この真空容器内を減圧状態にする排気機構15と、真空容器内に放電用ガスを導入するガス導入機構と、ガスを放電させプラズマを発生させるためマイクロ波による電力を供給する電力供給機構20,47と、真空容器内に設置される基板保持機構を備える表面処理装置であり、上記の電力供給機構は、誘電体44が充填された孔（スロット部43）を有する導電性板で形成されかつ真空容器内を真空封止するように真空容器に固定される平面状電極42を備え、導電性の板のスロット部を通して、電力供給機構の同軸管47で供給されるマイクロ波が真空容器内に放射されるように構成される。



内部に向うほど徐々に減少する。プラズマ生成に利用されるマイクロ波の周波数は一般的には2．45GHzが利用され、このときのECR条件を満足する磁束密度は875ガウスである。従ってリング状永久磁石19により発生する磁束密度がスロット18からやや離れた位置（具体的には数mmから数cmの位置）にECR条件を満足する875ガウスの等磁束密度面を生成するように、リング状永久磁石19の残留磁束密度を決定する。図6の例では、スロット18からECR面に至るプラズマ25中のマイクロ波の伝搬経路で、磁場強度が、ECR面に向かって次第に減少する構造を有する。また真空容器11内のスロット18の近傍におけるマイクロ波の電場32は磁場31とほぼ直交する。以上の2つの条件は、マイクロ波をECR面まで伝搬させて高密度のプラズマ25を発生させるために必要不可欠な条件である。

【0007】上記の従来の平面型ECR表面処理装置は、現在ではすでにプラズマ源としての評価が広く行われており、表面処理装置としての評価も広まりつつある。

【0008】

【発明が解決しようとする課題】ECR表面処理装置の最大の特徴は、磁場とマイクロ波の共鳴現象を利用することによって、低いガス圧力で高い密度のプラズマを発生できる点にある。しかし、通常利用されるマイクロ波の周波数である2．45GHzに対して共鳴条件を満足させるための磁場強度としては875ガウスが要求される。一方、半導体製造に利用されるシリコンウェハーは直径250mm程度のものが利用され、これを処理するためのプラズマもウェハー面積にわたって均一であることが要求される。

【0009】図5に示した平面型ECR表面処理装置では、複数のリング状永久磁石を使用することにより、一般的な空芯コイルにより磁場を発生させる形式の従来装置に伴う欠点を克服することができ、スロットの利用による大面積均一プラズマの発生、永久磁石の採用による磁場発生機構の簡便化、磁場がウェハー表面を横切らないことによる高周波電力バイアスの均一化等の効果が達成される。

【0010】しかしながら、上記平面型ECR表面処理装置は、マイクロ波の導入のための機構が複雑であり、特に同軸型真空窓24の信頼性が不十分であるために、供給できるマイクロ波電力が制限され、高密度プラズマの発生が困難であるという問題を有している。また、マイクロ波電力を大きくした際にはスロット18の周辺で異常な放電が発生するおそれもあり、装置としての信頼性の欠如から、現在のところ半導体製造ラインに導入されるには至っていない。

【0011】本発明の目的は、上記の問題を解決することにあり、新規な構造を有するプラズマ生成用平面状電極を提案し、高密度プラズマ発生時の信頼性を高め、低

圧力で高密度のプラズマを大面積にわたって均一に発生させることができる表面処理装置を提供することにある。

【0012】

【課題を解決するための手段および作用】第1の本発明に係る表面処理装置は、真空容器と、この真空容器内を減圧状態にする排気機構と、真空容器内に放電用ガスを導入するガス導入機構と、ガスを放電させプラズマを発生させるためマイクロ波による電力を供給する電力供給機構と、真空容器内に設置される基板保持機構を備える表面処理装置であり、上記の電力供給機構は、誘電体が充填された孔を有する導電性板で形成されかつ真空容器内を真空封止するように真空容器に固定される平面状電極を備え、導電性板の孔を通して、電力供給機構の同軸管で供給されるマイクロ波が真空容器内に放射されるように構成される。

【0013】第1の本発明では、マイクロ波導入に使用される従来の同軸管と真空窓を用いず、誘電体が充填された孔（スロット部）を平面状電極に形成し、同軸管を用いてこの平面状電極にマイクロ波を直接に供給し、当該孔からのマイクロ波の放射によって、均一性の良好な高密度プラズマを容易に発生する。平面状電極におけるマイクロ波の放射を行うスロット部としては誘電体が充填された孔がもっとも実用的である。またマイクロ波の電力を真空容器内に供給するための平面状電極の孔に誘電体を充填することによって、スロット部そのものを真空封止に耐える構造とし、従来、マイクロ波電力を供給するために必要であったが、信頼性に乏しかった同軸型真空窓を排除することが可能なった。

【0014】第2の本発明は、第1の発明において、平面状電極に形成された孔は導電性板上の一点を中心とする放射状位置に複数個配置され、かつ放射状位置の中心近傍にマイクロ波が供給されることを特徴とする。

【0015】第3の本発明は、第1の発明において、平面状電極の孔は1つの円上または複数の同心円上の弧として形成され、かつ円または複数の同心円の中心近傍にマイクロ波が供給されることを特徴とする。

【0016】第2および第3の本発明では、スロット部を形成する孔は、好ましくはリング状の放射状位置に配置されており、マイクロ波による電力が有効に真空容器内に放射され、プラズマを放電空間内に生成せしめ、これを利用することを可能とした。

【0017】第4の本発明は、第1から第3の発明において、平面状電極を形成する導電性板で孔と干渉しない位置に複数個のリング状永久磁石を設置し、孔の近傍に磁場を発生したことを特徴とする。

【0018】第5の本発明は、第4の発明において、複数のリング状永久磁石の着磁方向はリング状永久磁石の半径方向であり、かつ隣り合うリング状永久磁石の着磁方向が互いに逆方向であることを特徴とする。

設置されたスロット部４３の誘電体４４を通して、真空容器１１の内部にマイクロ波による電力が放射される。このマイクロ波電力は、真空容器１１内に導入されているガスに吸収され、真空容器１１内にプラズマ２５が発生する。このプラズマ２５の持つ作用を利用して、被処理基板１４の表面に所定の表面処理を施す。このとき、複数のリング状永久磁石４５から発生する磁場の強度を、供給されるマイクロ波の周波数に対する電子サイクロトロン共鳴の条件が真空容器１１内におけるスロット部４３の近傍空間で満たすように設定すれば、プラズマ２５の発生効率を非常に高いものとすることができる。

【００２８】マイクロ波導入部の構造に関して説明する。表面処理装置において利用するマイクロ波の電力は、通常１０Wから数ｋWの範囲にある。このような電力を伝搬させるための同軸管４７としては、外部導体４８の内径が２０ｍｍまたは３９ｍｍに規格化されたものを利用するのが一般的である。一方、スロット部４３の直径に関しては、目的とするプロセスに応じて異なるが、通常は被処理基板１４の直径と同程度もしくは若干小さい程度の直径が必要とされる。被処理基板１４の直径は１５０ｍｍから３００ｍｍの範囲に大部分のものが含まれるため、スロット部４３と同軸管４７とは直接的に接続することはできない。従って、本実施例では、外部導体４８および内部導体４９の放電用平面状電極４２と接続する部分４７ａをテーパ状とした同軸管４７により構成している。これによって、インピーダンス不整合による電力利用効率の悪化を防止している。

【００２９】図３を用いて磁場とマイクロ波による電場との作用を説明する。図３では、リング状永久磁石４５により発生する磁力線（磁場）５０、平面状電極４２に設けられたスロット部４３により発生するマイクロ波の電場５１が示される。スロット部４３からＥＣＲ面に至るプラズマ５２中のマイクロ波の伝搬経路で、磁場強度がＥＣＲ面に向かって次第に減少する構造を有する。またマイクロ波による電場５１は、ほぼ全体にわたって磁力線５０と直交する。以上の２つの条件は、従来の技術の項ですでに述べた通り、マイクロ波をＥＣＲ面まで伝搬させて高密度のプラズマを発生させるためには必要不可欠なものである。本実施例においても、複数のリング状永久磁石４５の着磁方向を半径方向とし、かつ隣り合うリング状永久磁石４５の着磁方向を互いに逆方向とすることにより、図３と図６の比較から明らかなように、従来の平面型ＥＣＲ表面処理装置と同様の磁場と電場の相互作用が可能となり、ＥＣＲの利点を生かしたプラズマの生成が可能である。

【００３０】図４は本発明に係る表面処理装置の第２の実施例を示す。この実施例では、スロット部４３は平面状電極４２の内部にて半径方向にクランク状に形成されており、第１の実施例と同様に誘電体４４が充填されている。スロット部４３の位置は、大気側の電極面においては内側から２番面と３番目の２つのリング状永久磁石５３の間とし、真空側の電極面においては２番面のリング状永久磁石５３の磁石幅の中心位置と合わせることが望ましい。このスロット部４３内に充填する誘電体４４の材質は、第１の実施例と同様に選択される。また本実施例では、複数のリング状永久磁石５３の着磁方向は、従来装置の場合と同様にリング形状の軸方向とする。これは、本実施例においては磁場とマイクロ波電場との配置関係が、図６に示した従来装置の場合と同様になるからである。

【００３１】上記の各実施例では、リング状永久磁石４５，５３を平面状電極４２に組み込むようにしたが、平面上電極４２の外側に配置することもできる。

【００３２】

【発明の効果】以上の説明で明らかなように本発明によれば、平面型ＥＣＲ表面処理装置において、平面状電極の構造およびリング状永久磁石の着磁方向に工夫することによって、信頼性低い従来のマイクロ波導入用真空窓を排除し、スロット内部での不要放電の発生をなくしたため、平面型ＥＣＲ表面処理装置において安定して効率よく高密度プラズマを発生させ、かつ被処理基板に表面処理の均一性を良好に保つことができ、実用性を高めた。特に、本発明によれば、プラズマプロセス装置であるドライエッチング装置、ＣＶＤ装置等の表面処理装置において、各種の高速かつ均一な大面積処理が可能となる。

【図面の簡単な説明】

【図１】本発明に係る表面処理装置の第１実施例を示す断面図である。

【図２】平面状電極の構造を説明するための平面図である。

【図３】第１実施例における磁場とマイクロ波による電場との作用関係を説明するための断面図である。

【図４】本発明に係る表面処理装置の第２実施例を示す断面図である。

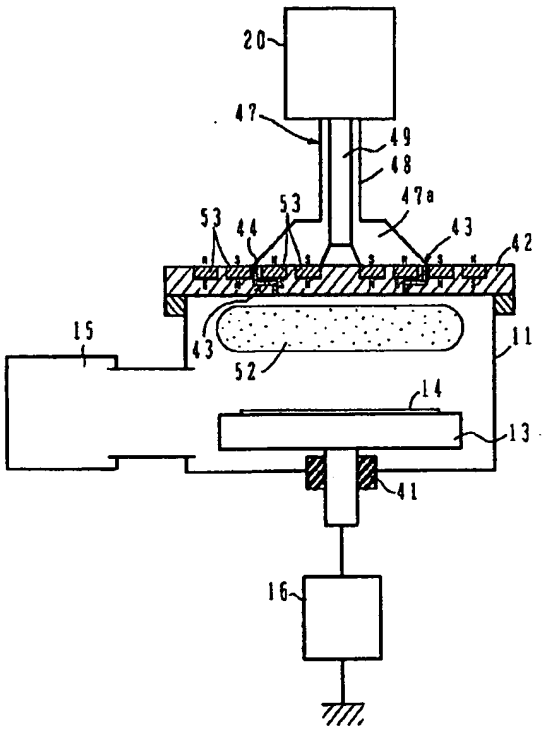
【図５】従来の平面型ＥＣＲ表面処理装置を示す断面図である。

【図６】従来の平面型ＥＣＲ表面処理装置における磁場とマイクロ波による電場との作用関係を説明するための断面図である。

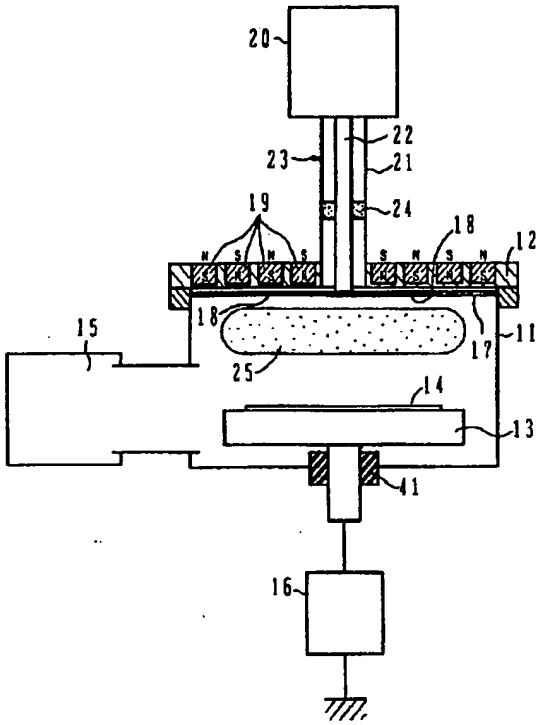
【符号の説明】

１１	真空容器
１３	電極
１４	被処理基板
１５	排気機構
４２	平面状電極
４３	スロット部
４４	誘電体
４５，５３	リング状永久磁石
４７	同軸管

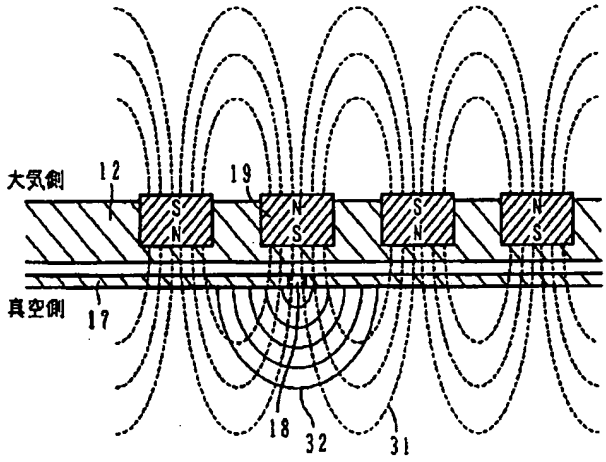
【図4】



【図5】



【図6】



フロントページの続き

(51)Int.Cl.⁶	識別記号	庁内整理番号	FI	技術表示箇所
C30B 33/12		7202－4G		
H01L 21/205				
H05H 1/46		C 9216－2G		